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EXAMINER	
KIELIN, ERIK J	

ART UNIT	PAPER NUMBER
2813	

DATE MAILED: 10/25/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/977,069	RAMANATH ET AL.	
	Examiner	Art Unit	
	Erik Kielin	2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *12 October 2004*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *6-9,11 and 13-18* is/are pending in the application.

4a) Of the above claim(s) *none* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *6-9,11 and 13-18* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

This action responds to the Amendment filed 12 October 2004.

Claim Rejections - 35 USC § 112

1. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

2. Claims **6**-9, 11 and **13**-18 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

Independent claims 6 and 13 have been amended to include the limitation that the SAM diffusion barrier has "a trimethoxy silane group." This is not enabled by the instant specification. As a matter of fact, the instant specification directly contradicts this. Rather the SAM barrier layer is formed by a reaction with the silicon or silicon oxide surface of the substrate by elimination of each of the methoxy groups. Accordingly, there is no trimethoxy silane group in the SAM barrier layer. For verification, see US Patent Application Publication 2002/0079487 A1 to the same inventive entity of the instant invention --especially paragraphs [0031]-[0045]. See also the article cited by Applicant in the instant specification to Dressick et al. as listed in the paragraph bridging pages 3-4.

Examiner notes with interest that the inventors of the instant invention would attest that the as-deposited SAM barrier layer has a trimethoxy silane group --by the submission of the

instant Amendment-- when the inventors attested to **exactly the opposite** in a related application, i.e. that the SAM diffusion barrier layer does NOT have a trimethoxy silane group. It is furthermore, unclear how the instant inventors could be unaware of the basic chemistry leading to the barrier layer when it is clearly delineated in the related 2002/0079487 A1 publication.

The remaining claims are rejected for depending from the above rejected claims.

3. Claims 6-9, 11 and **13**-18 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

Based upon the same evidence that the SAM diffusion barrier layer does not have a trimethoxy silane group, the inclusion of the trimethoxy silane group into the claims 6 and 13, as well as the claims depending therefrom, amounts to the inclusion of new matter.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 6-8 and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 5,079,600 (**Schnur** et al.) in view of ASM Handbook Vol. 5, Surface Engineering, ASM

International: Materials Park, Ohio, 1994, pp. 315-318, and the basic textbook by **Porterfield**, Inorganic Chemistry, A Unified Approach, Addison-Wesley: Reading, Massachusetts, 1984, pp. 487-488.

Regarding claim 6, **Schnur** discloses a semiconductor device comprising,

(a) a substrate (Fig. 1A);

(b) a diffusion barrier (Fig. 1A, called "thin film"), wherein the diffusion barrier comprises a self-assembled monolayer, SAM, (col. 10, lines 42-47) including a plurality of molecules, each molecule having an aromatic group at the terminus of the molecule. (For example, EXAMPLE 28 at col. 21, discloses a SAM formed from trichloro-(4-pyridyl)-ethyl-silane which forms the equivalent SAM barrier layer as shown in structure entitled "1" on p. 7 of the instant specification. The pyridyl is an aromatic group.

(c) a metal layer (called "catalyst" and "metal layer") on the diffusion barrier.

In pertinent part, **Schnur** states in col. 20,

> "EXAMPLE 24
> "Fabrication of MOS capacitor test structures."
> "An n-type silicon wafer with a 100 nm thick thermal oxide layer was cleaned and treated with UTF3 as in example 14. The film was patterned using a mask with standard capacitor test structures and irradiated for 28 minutes with an Hg/Ar lamp. The wafer was metallized with the standard copper plating procedures, used in Example 5, yielding metal squares 800 microns on a side (area=$6x10^{-3}$ cm^2). The metal/thermal oxide/n-type silicon (MOS) capacitors were then characterized by probing the metal pads and the back of the wafer with a Micromanipulator automatic C-V measuring system. The capacitance was found to be 26 pF/cm^2 with minimal (10 mV) hysteresis and remained stable at room temperature for at over 3 weeks, indicating that device degradation due to masked metal contamination **(diffusion of copper into the thermal oxide) was not a problem**." (Emphasis added.)

Accordingly, it is seen to be inherent that the SAM of **Schnur** is a diffusion barrier because **Schnur** states that "diffusion of copper into the thermal oxide" does not occur.

(See also section entitled, "Summary of the Invention") the sections entitled "EXAMPLE 1" col. 11, lines 24-58 wherein the barrier layer is formed from "octenyldimethylchlorosilane" covalently bonded to the substrate. See also "EXAMPLE 3" and "EXAMPLE 5.")

It is held, absent evidence to the contrary, that the diffusion barrier is inherently capable of preventing the diffusion of copper atoms from the metal layer into the substrate when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm at 200 °C in flowing N_2, because **Schnur** shows by empirical evidence that the SAM functions as a diffusion barrier. Because the **Schnur** SAM barrier layer it is the same exact molecule formed on a silicon substrate using the exact same precursor as used in the instant application, the barrier layer properties must be the same. **Schnur** also points out in Example 24 that copper diffusion does not occur even under the stress of an electric field.

Further in this regard, there exist no means for Examiner or the USPTO to determine the diffusion barrier properties of the **Schnur** barrier layer under the specific conditions that Applicant is claiming. Simply because Applicant ran a test for diffusion barrier properties under a specific set of conditions does not make the diffusion barrier novel and non-obvious over the barrier layer of **Schnur**. Applicant has the burden of proof of showing that the Schnur copper barrier layer does not operate as barrier layer under the claimed conditions. To do otherwise would take away from the public that which has already been given to the public many years ago by **Schnur**. See *In re Swinhart*, 169 USPQ 226,229 (CCPA 1971) (where the Patent Office has reason to believe that a functional limitation asserted to be critical for establishing novelty in the

claimed subject matter may, in fact, be an inherent characteristic of the prior art, it possesses the authority to require the **applicant to prove that subject matter shown to be in the prior art does not possess the characteristics relied on)** and *In re Fitzgerald*, 205 USPQ 594 (CCPA 1980) (the burden of proof can be shifted to the applicant to show that subject matter of the prior art does not possess the characteristic relied on whether the rejection is based on inherency under 35 USC 102 or obviousness under 35 USC 103). Note that as long as there is evidence of record establishing inherency, failure of those skilled in the art to contemporaneously recognize an inherent property, function or ingredient of a prior art reference does not preclude a finding of anticipation. (See MPEP 2112.)

Schnur does not teach that the catalyst is copper, thereby having the limitation that "for each molecule of the plurality of molecules, the copper in the metal layer is in direct contact with the aromatic group of the molecule."

ASM Handbook teaches that copper may be used as a catalyst for electroless plating of copper (pp. 315-318 --especially p. 318 sections entitled, "Catalyzation" and "Copper catalyst"). The basic textbook of **Porterfield** ensures that copper forms metal complexes with pyridine groups, such as the pyridine group used in **Schnur** as the polar end-group of each molecule in the SAM barrier layer.

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use copper as the metal catalyst in **Schnur** as taught in the **ASM Handbook** because **Schnur** is not limited to Pd/Sn catalysts, as at least claim 1 of **Schnur** makes clear, and because copper is a known catalyst for electroless copper plating, as used in **Schnur**, as taught by the **ASM Handbook**. In this regard, it has been held that the selection of a known material based upon its

suitability for an intended purpose is obvious. Moreover, the **ASM Handbook** teaches that copper-based catalyst are less expensive that palladium-based catalyst, thereby providing additional motivation to use copper for cost savings.

Schnur only requires that the catalyst bond to polar end group of the molecule which is the pyridyl end group of "Example 28" in **Schnur**. **Porterfield** ensures that such bonding occurs, such the one of ordinary skill has a reasonable expectation of success for using copper instead of Pd/Sn, as the catalyst in **Schnur**. Accordingly, using copper as the catalyst gives the limitation, that "for each molecule of the plurality of molecules, the copper in the metal layer is in direct contact with the aromatic group of the molecule."

Regarding claim 7, as noted above, Example 24 in **Schnur** states that the substrate is a silicon wafer with silicon oxide formed thereon.

Regarding claim 8, **Schnur** discloses the linear carbon chain of trichloro-(4-pyridyl)-ethyl-silane is the ethyl group, which has at least 2 carbon atoms.

Regarding claim 12, the metal layer is in direct contact with the terminal groups of the molecules in self-assembled monolayer (Fig. 1A). Note that the "catalyst" is a metal and therefore forms part of the "metal layer."

6. Claims 9, 11, and **13**-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Schnur** in view of the **ASM Handbook** and **Porterfield**, as applied to claims 6-8 and 10 above, and further in view of **Wolf**, et al. Silicon Processing for the VLSI Era, Vol. 1-Process Technology, 2nd ed., Lattice Press: Sunset Beach CA, 2000, pp. 438, 782-783.

Regarding claims 9 and 13, **Schnur** discloses each of the claimed features, as explained above, but does not indicate that the metal layer is deposited by a vapor deposition process, using in the exemplary embodiments, electroplating. **Schnur** does, however, indicate that the metal deposition method is for use in interconnect for semiconductor microcircuitry (Abstract, Example 25 in col. 20.)

The basic textbook of **Wolf**, teaches that copper metal interconnect may be deposited by a variety of methods, including electroplating and vapor deposition methods such as PVD (e.g. sputtering) and CVD. (See pp. 782-783--especially p. 783, last paragraph before section 15.8.2.)

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use a vapor deposition process, such as sputtering to deposit the metal layer in **Schnur**, because vapor deposition processes (i.e. PVD and CVD) are an art recognized equivalent means to the electroplating used in **Schnur** to form copper interconnect, as taught by **Wolf**.

Further regarding claim 13 and regarding claim 17, it is held, absent evidence to the contrary, that the diffusion barrier of **Schnur** is capable of preventing the diffusion of metal atoms from the metal layer into the substrate when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm at 200 °C in flowing N_2 (claim 17) and that the semiconductor device does not exhibit $j_{leakage} > 1000\ nAcm^{-2}$ when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm in flowing N_2 at 200 °C for up to 650 minutes (claim 19). The basis for this reasoning is the same as applied to claim 10 above whose arguments are incorporated herein in their entirety. In short, equivalent structures must be capable of serving the same function. The structures in the instant specification are equivalent to those disclosed in **Schnur**.

Regarding claim 11, in Example 25 (col. 20) in **Schnur** the diffusion barrier coats the walls of a polysilicon steps, but it is unclear if the metal fills a hole in the substrate. But as noted above, **Schnur** states that the method is used for interconnect.

The basic textbook of **Wolf** teaches that copper interconnect fills a hole in a substrate lined with a barrier layer to form interconnect for semiconductor microcircuitry (Fig. 15-52, pp. 782-783).

It would have been obvious for one of ordinary skill in the art, at the time of the invention to form the metal interconnect of **Schnur** in a hole, because **Wolf** teaches that this is standard practice in the art for forming copper interconnect.

Regarding claims 14 and 18, as noted above with respect to claim 7, Example 24 in **Schnur** states that the substrate is a silicon wafer with silicon oxide formed thereon.

Regarding claim 15, as noted above with respect to claim 8, **Schnur** discloses that the linear carbon chain of trichloro-(4-pyridyl)-ethyl-silane is the ethyl group, which has at least 2 carbon atoms.

Regarding claim 16, although **Schnur** does not teach sputtering, as noted above with respect to claim 9, **Wolf** teaches that PVD (of which sputtering is a member; Wolf, p. 438) is an art recognized means to electroplating to deposit metal films for interconnect.

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use a vapor deposition process, such as sputtering to deposit the metal layer in **Schnur**, because vapor deposition processes (i.e. PVD and CVD) are an art recognized equivalent means to the electroplating used in **Schnur** to form copper interconnect, as taught by **Wolf**.

Response to Arguments

7. Applicant's arguments filed 12 October 2004 have been fully considered but they are not persuasive.

Applicant opines on p. 7, first paragraph that "...Schnur et al. does not disclose a diffusion barrier." Examiner respectfully disagrees based upon the fact the Schnur expressly shows that the SAM layer acts as a diffusion barrier to copper diffusion into SiO_2. Accordingly, Applicant's opinion is of no merit. Applicant ignores the facts of record.

Applicant opines on p. 7, under the section entitled, "Response,"

> "However, **the present claims do not recite the use of a catalyst at all. It cannot therefore be obvious to substitute one catalyst for another**." (Emphasis in original.)

Examiner respectfully disagrees. First this is a *non sequitur*. That which is instantly claimed is immaterial to what an external party (e.g. one of ordinary skill) would glean from the references of Schnur and the ASM Handbook --especially when the external party is not privy to the instant claims. Second, as Applicant's Representative should be well aware, obviousness is not predicated upon that which Applicant **claims**, but is rather predicated upon that which one of ordinary skill would find obvious considering the combined teachings of the applied references. So long as the combination is obvious and reads-on the claims, a *prima facie* case of obviousness has been properly established.

In this case, Schnur uses an exemplary catalyst/seed to deposit copper on the barrier layer. ASM Handbook teaches alternative catalyst/seed materials which are less expensive than those used in Schnur. The basic textbook of Porterfield provides evidence of success for the substitution of the catalyst/seed materials. Accordingly one of ordinary skill would be motivated

to used the less expensive catalyst to save money, knowing that there exists a reasonable expectation of success.

Applicant argues that the catalyst is not a metal layer. Examiner respectfully disagrees. A metal is a metal is a metal.

Applicant argues,

> "**The use of a trimethyoxy silanegroup is not taught or suggested by Schnur et al**." (Emphasis in original.)

First, this argument is irrelevant since the instant Applicant's attested in a related application, published as 2002/0079487 A1, that the SAM diffusion barrier layer does NOT have the trimethyoxy silane group. Instead, it is merely used to deposit the SAM. Should, however, Applicant be attempting to import a process limitation into device claim, Applicant should be aware that method limitations do not have patentable weight in device claims absent **evidence** -- **not opinion**-- showing differences in the products. Further in this regard, Applicant is reminded that in the Office action filed 21 August 2002, the patent US 5,389,496 to Calvert et al. uses the trimethoxy silane substituent as opposed to the trichloro silane substituent. They behave the same chemically, i.e. the choro and methoxy groups are leaving groups that enable the silicon atom to bond to the silicon oxide via an oxygen atom of the silicon oxide. Moreover, the instant inventors attest in US Patent Application Publication 2002/0079487 A1, paragraph [0051], that the trichloro silane substituent group works well as the trimethoxy silane group.

Conclusion

8. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Erik Kielin whose telephone number is 571-272-1693. The examiner can normally be reached on 9:00 - 19:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead, Jr. can be reached on 571-272-1702. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Erik Kielin
Primary Examiner
21 October 2004